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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	MM Docket 93-177
An Inquiry into the	)	RM-7594
Commission's Policies and Rules	)	
Regarding AM Directional Antenna	)	
Performance Verification	)	

Comments of Hatfield & Dawson Consulting Engineers, Inc.

INTRODUCTION

On December 15th 1989, the firms of duTreil, Lundin & Rackley Inc., Hatfield & Dawson Consulting Engineers, Inc., Lahm, Suffa & Cavell, Inc., Moffett, Larson & Johnson, Inc., and Silliman & Silliman filed a Petition for Inquiry, requesting that the Commission open a general inquiry into the Commission's Rules regarding the performance verification of AM directional antenna systems. The Commission adopted a Notice of Inquiry regarding this matter on June 14, 1993.

Evidence has been steadily accumulating leading toward the conclusion that the use of modern analytical techniques allows the performance of medium wave directional antennas to be predicted, established, and maintained without the elaborate methods that were necessary in the past. As a result, a complete change in the philosophy of medium wave directional antenna performance verification is appropriate.

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Technical Characteristics of Medium Wave Directional Antennas and the Propagation Environment

It has been well known since the 1930's that the behavior of the vertical monopoles generally used as elements in directional antenna arrays is not simply described. These effects and measurement techniques to determine actual current distribution were described in 1937 by George Brown. Techniques for calculation were developed in the late 1940's by Schelkunoff. However, evidently for reasons of practical simplicity, the 1939 "Standards of Good Engineering Practice," which outlined the basic assumptions for directional antenna analysis assumed sinusoidal current distribution, and this assumption has been carried forward to the present day.

The groundwave and skywave field strength calculations mandated by the Commission's rules have suffered from equally invalid simplifying assumptions. The circumstances of groundwave field strength calculation are more straightforward than those of skywave field calculation, but in both cases the assumptions of the 1930's should be examined critically. The basis for virtually all methods in use for skywave field calculation are measurements of signal strength conducted largely in the 1930's and 1940's. Although these measurements can no longer be replicated, due to the worldwide increase in medium wave emitters, researchers have used this data in attempts to more precisely define anticipated skywave field strengths. The difficulty with this process is that the basic underlying data is questionable since little or no effort has been made - if indeed such effort is now possible - to evaluate the total radiating characteristics of the individual radiating sources used in the measurements. Indeed, in most cases the basic characteristics of the radiating antennas and their surrounding environment are not a part of the data, and in some cases they are not even known. As a result, the actual radiation for low vertical angles and therefore long distance skywave fields is not known. The current distribution of the radiating antennas is not a part of the data, and therefore the actual radiation of the antennas at higher vertical angles is not known.

Skywave calculation methods frequently employ a range of pertinent vertical angles. The basis for this appears to be related to measurements showing skywave fields which are inconsistent

with single angle theory. It is reasonable to assume a varying height for the effective ionospheric reflection. However this type of analysis appears to overlook entirely the departure of practical radiating elements from sinusoidal current distribution.

Analysis of the evident poor supression performance of medium wave directional antennas may derive from oversimplified assumptions about vertical radiation characteristics. OCE TRR Report 1.2.7 attempts to provide an explanation of this effect. This analysis is an excellent one, but it too appears to ignore the non-sinusoidal behavior of radiating elements.

The circumstances for groundwave analysis are somewhat better, but still suffer inaccuracy due to assumptions about uniform dielectric constant that make them questionable for circumstances where there are large changes in the surface conditions along propagation paths. The February 1986 "Eckert" methods, as well as those of Leslie Berry developed for NTIA, are very accurate within their limitations, but when the curves they produce are used for graphical analysis of measured data to establish effective values of conductivity and radiating field, one is still attempting to solve a two-variable problem with a single equation.

Measurements themselves have never been simple, and they and their interpretation have grown more difficult as the measurement environment has grown more complicated. The profusion of wires and metallic vertical scatterers that is characteristic of urban places has spread to include rural areas as well. The distortion of the relationship between electric and magnetic field strength has been shown by Causebrook, based on measurement data from a moderate sized British city. As a consequence of the effects described by Causebrook, the use of farfield magnetic field measurements to show array behavior frequently results in error.

The presence of conducting objects sufficiently close to medium wave arrays to exhibit substantial mutual coupling produces profound distorting effects in the apparent radiation pattern as measured along the ground. The traditional methods of array measurement and adjustment frequently result in substantial "mistuning", to produce a horizontal plane pattern that can be shown to be consistent with the theoretical one, and contained within the so-called "standard pattern" envelope. Modern analytical methods are, in fact, sometimes employed to produce this

mistuning and to justify its horizontal plane measured results, despite the fact that the effects on the vertical radiation pattern, especially the minima areas of the pattern, may result in profound undesirable radiation.

In summary, the measurement environment, together with the uncertainty of many of the requirements for medium wave directional antenna performance, leads to the conclusion that the present methods of performance verification are inadequate and inaccurate. The total medium wave allocation situation would almost surely benefit from a situation where all arrays were adjusted to internally monitored models of their performance, rather than to uncertain external measurements.

Specific Rulemaking Action Advised

A Notice of Proposed Rulemaking should contain the following proposed changes in the Rules:

An application for licensing of a new directional antenna system or for a revised license for an existing directional antenna system should include submission of an analytical study of the anticipated antenna monitor values which will result from proper operation of the array. This analysis should be performed using moment method analysis or other justifiable numerical modeling techniques, and should result in calculated operating conditions which produce the correct far field horizontal plane pattern. Suitable standards for the modeling process should be developed as a result of a Notice of Proposed Rulemaking.

The monitoring system used should be constructed to very high standards. The antenna monitor should meet the general requirements now used for so-called "critical arrays." The sample system RF cabling interconnections should be stable low loss highly shielded coaxial cables. Monitoring elements should be employed which detect the phase and amplitude of base voltages, and current monitors at locations on the radiators should be required for towers above a suitable minimum height. The performance verification report should contain a complete sample system test plan report, including measurements of the lengths of all sample lines, and verifications of the specific phase and amplitude characteristics of each sample monitoring element.

No field strength measurements, and therefore no graphical analysis, maps or other data should be required. Since no measurements should be required, no measurement analysis or supporting documentation is required. Since the pattern characteristics for all allocation purposes are provided by the Standard Pattern, no plotted pattern should be required.

Compliance with the limits of the Standard Pattern value should be assumed if the antenna monitor ratio and phase values are within a specified range from the predicted values. For example, a tolerance of $\pm$1.5 degrees and $\pm$2.5% sample amplitude ratio from the anticipated values for the antenna design may be appropriate. These values are 1/2 of the normal operating tolerance for "non-critical" antenna systems. The designation of antenna systems as so-called "critical arrays" should be eliminated. This practice is especially unreasonable since it has been based entirely on the complaint of allegedly aggrieved parties and not applied uniformly to all proposals.

The Notice of Proposed Rulemaking should revisit the performance requirements (as opposed to the former specific equipment requirements) of the antenna sampling system rules. The elimination of field measurement as the primary performance evaluation tool will produce even greater dependence on the antenna array sampling system than is now the case, and therefore these requirements are critical to the proper operation of an array on a day to day basis. It can be shown, for example, that the use of voltage sample monitoring at the base of the radiating element has several profound advantages, although it may be appropriate to employ current sample loops above the base of radiators taller than, say, 115 degrees, in addition to base voltage samples.

A Conference of Interested Parties May Be Advisable

Because the matters suggested in the Notice of Inquiry are complex, and because there may be substantial differences of opinion among qualified experts on medium wave antenna matters, a conference or forum of interested parties would be a suitable procedure to develop specific proposed rule changes for an NPRM.

October 26, 1993

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